Archeology and Metallurgical Technology in Prehistoric Afghanistan, India, and Pakistan[1]

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Recent research in India and Pakistan has greatly increased our knowledge of the Indus Civilization. Geographically the most widely distributed of Old World prehistoric civilizations, its origin and decline are, nevertheless, still little understood. The earliest metallurgical technology, represented in the chalcolithic cultures of Afghanistan and Baluchistan, points to an early connection with Iran. With the later inception of the Indus Civilization, metallurgy, derived apparently from the west, is technically an accomplished craft. Technological processes and typological occurrences of metal objects are discussed. The metal "hoards" of the Ganges-Jumna are without parallel and are seen as a separate metallurgical tradition within India.

THERE have been very few attempts to synthesize the nature and extent of cultural traits—pottery, architecture, metallurgy, etc.—in the whole area of prehistoric Afghanistan, India, and Pakistan. With metallurgy as its primary focus, this paper is such an attempt. In addition to providing the descriptive detail for the development of a metallurgical technology and the distinctive metal types, the paper deals with the following questions:

1. What is the evidence for a developing metallurgical technology in this area?
2. Where were the ore deposits located, and what is the nature of the ores?
3. What techniques of production were used by the smiths?
4. What do we know of the material culture involved—of their bellows, fuel, crucibles, smelting operations, smith's tools, furnaces? (There is a nearly complete absence of data here.)
5. What are the most characteristic metal tool types? What are their functions, and what behavioral characteristics can be deduced from them?
6. How reliable are these metal types for establishing cultural synchronisms in the area?
7. To what extent do Indus metal types reflect those evident further to the west, and vice versa?

These questions—some of which can be answered from the available evidence and some of which, unfortunately, cannot—are of basic importance in dealing with the earliest evidences for metal production in the Baluchistan, the Indus, and the Ganges-Jumna cultures.

Though a sophisticated technology of metal-working in copper and bronze was known to the people of the Indus Civilization, lack of confidence in the stratigraphy of the important sites makes any attempt at tracing the developmental stages of this craft most difficult. In the earliest levels of the sites in the Indus Valley and Baluchistan, a wide range of copper objects appears. Since the metallurgical technology in these earliest levels was far beyond an experimental stage, we must look elsewhere—toward Iran and Mesopotamia—for its origins.

The available evidence for a metallurgical development in India and Pakistan indicates an early connection with Iran. There the site of Tepe Sialk (Ghirshman 1938), where a sequence of developing metallurgical techniques can be placed in a context of successive levels, provides one of the first examples of a developing metal technology (Coghlan 1951:32). Copper objects of Period I_3, dated to around 4800 B.C., were produced by simple cold-hammering, as were those throughout Period II (Wertime 1964:1260–1262). In Period III_4, dated to around 3250 B.C., copper objects were manufactured in open molds; Period III_5 provides the first evidence for the use of closed molds. In Period IV smelting processes are evident, as well as the development of *cire perdue* techniques (Ghirshman 1938:16,30,52). The techniques evident above at Sialk are all

chronologically earlier than their documented appearance in India and Pakistan.

The importance of the Kerman Mountain area in southeastern Iran to the development of metallurgical processes has only recently become evident. Excavations at Tal-i-Iblis in the Mashiz Valley have uncovered crucibles that on analysis suggest the presence of the earliest-known smelting operations, dated to *ca.* 4000 B.C. (Caldwell and Shahmirzadi 1966: 11–13).

From the excavations at this site it also becomes increasingly evident that this area—situated between the better-known cultures of Iran to the west and those of the Baluchi hills to the east—played a major role in the dissemination of technologies from Mesopotamia and Iran toward the east. Trade for copper ore, in which the Kerman Range is believed to be rich (T. A. Wertime, personal communication), may well have stimulated this. The recently recovered beveled-rim bowls at Tal-i-Iblis, identical to their Mesopotamian counterparts, attest to such long-distance contacts *ca.* 2800 B.C. (Caldwell and Shahmirzadi 1966:17). Pottery from the Valley of Balūk, east of Tal-i-Iblis, at Darūyi and Tappa-i-Nūrābād—collected by Sir Aurel Stein, now in the collections of the Peabody Museum, Harvard University, and recently studied by the author—suggests strong typological similarities with the wares from Tal-i-Bakun (Langsdorff and McCown 1942) as well as those from Chah Husseini, near Bampur (Stein 1937:126–131), and Rana Ghundai I and II (Ross 1946:291–315).

PRE-HARAPPAN MATERIALS IN AFGHANISTAN AND BALUCHISTAN

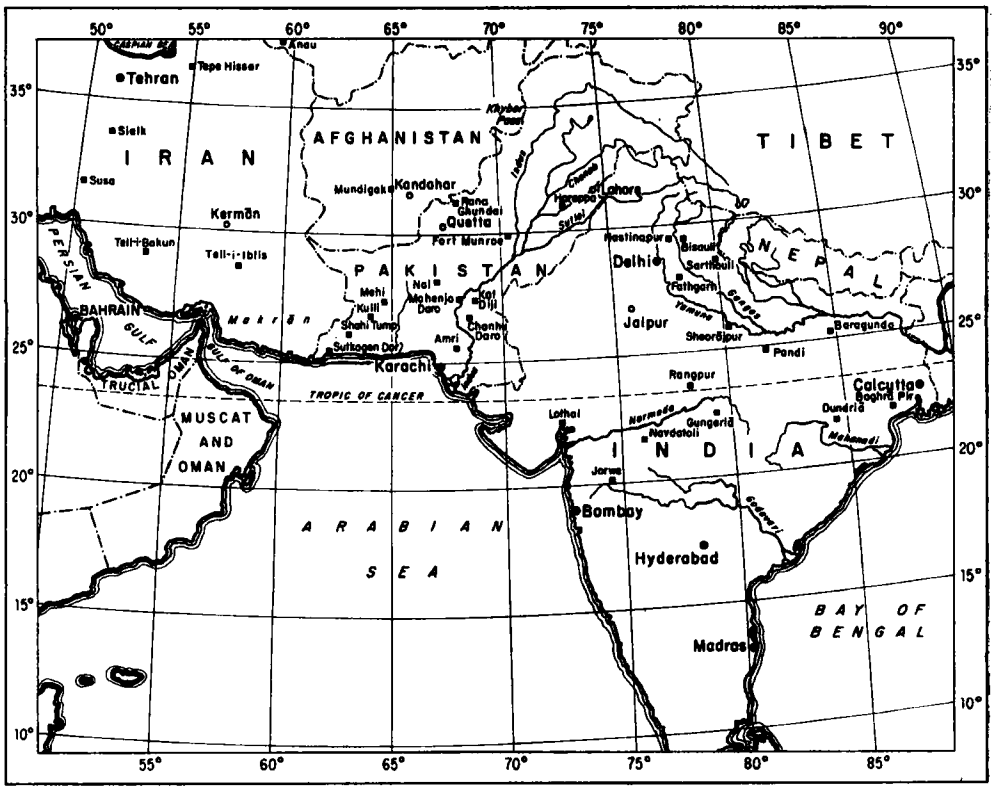
Dales (1965) has recently attempted to build an internal framework, correlating total archeological assemblages, in terms of a succession of "phases" for Afghanistan, Baluchistan, and the Indus Valley. These phases "refer to cultural horizons consisting of distinctive material assemblages and representing specific levels of cultural, social, and economic development" (1965:257). Abstract designations, alphabetical rather than socioeconomic or technological, were used for these phases (A–F). Thus, Phase A encompasses the initial stages of human habitation in the area—the Early Stone Ages.

Metal appears in Pakistan and Afghanistan at the beginning of Phase C (no absolute dates for this phase are available, *ca.* 3000 B.C.?), and then only in the western part of the Baluchistan area: Quetta and Mundigak (Fairservis 1956:231; Casal 1961:245).

Although the hollow copper tubes found at Deh Morasi in IIa context are said to resemble those from later Gawra XI (Dupree 1963:116), they are also similar to those found in Hissar II levels (Schmidt 1937:207, Pl.54) at a time much nearer to the postulated data of *ca.* 2800 B.C. for Deh Morasi IIa. More important and more relevant to the dating of the initial appearance of metal tools in this area is the evidence from Mundigak in Afghanistan (Casal 1961). The achievement of copper-tin alloying appears for the first time at Mundigak in Level III_6 (axe with 5% tin, 1961:247); unalloyed copper implements and fragments, however, appear from the start in almost every level. Mundigak provides us with the earliest-known metal in this area and suggests a date of *ca.* 3100 B.C. for the inception of a metallurgy in Afghanistan.

Thus, the earliest occurrence of metal in Afghanistan, India, and Pakistan is placed over two thousand years after its first appearance at Sialk, and over three thousand years after its initial appearance in Iran at Ali Kosh (Hole 1962:97–148). It is suggestive that Dales (1965:261–264, 275) finds strong parallels throughout Phase C among the assemblages of Mundigak I, Sialk III, and Hissar I. It is during this period of increased contact that metal makes its first appearance at Mundigak.

There seem to be two distinct outside influences acting on the ceramic styles of Mundigak, and these may be reflected in its development of metallurgical technology. After the settlement of the site briefly by seminomadic people, characterized by pinkish handmade pottery in Period I_1, an influence from the west can be detected in Period I_2, with wheelmade pottery believed to be similar in some respects to Jemdet Nasr ware, painted with hanging triangles, garlands, and hatched lines (Casal 1964b:76; this attribution is, however, not very convincing). This same substratum sees the first introduction of metals, in the form of thin elbowed blades (*lame coudée*) of copper (Casal 1961:247). A similar blade is found in Period I_4 (1961:Fig. 139, no. 1), together with a copper awl (1961:Fig. 139, no. 2); presumably both were cold-worked. In Period I_{3-5} at Mundigak the humped bull is



introduced, together with Amri influences in pottery and architecture. These influences coincide with the initial presence of metal at Amri in the earliest levels (Casal 1964a:57 ff.), Dales's Phase D, which suggests the introduction of metals at Amri from Mundigak.

Period II at Mundigak appears to be one of slow development and growth, resulting perhaps in the isolation of the settlers from their western homelands. In Period II_3 eyed needles appear, along with tanged daggers, elliptical in section with midrib (Casal 1961:Fig. 139, no. 3), and a pin with a double volute head, the spiral being turned in the opposite direction to that of their Eastern Mediterranean counterparts (1961:Fig. 139, no. 4).

Period III, assigned to Dales's (1965:262–268) Phase D, introduces the second major impulse into Mundigak, stemming from the northwest, apparently from Iran. This second impact can be detected in changes of pottery as well as in the introduction of new metal shapes. The decoration on the pottery is a brown-red on pink-white, characterized by simple wavy line designs. Also, the increased use of Amri and Quetta pottery motifs and the introduction of the Harappan pipal leaf motif suggest that this was a period of increased communication within and to the west of the Baluchi hills. The striking innovation in metallurgy is the introduction, in Period III_6, of copper-tin alloying (mentioned above) and of the shaft-hole axe and adze (Casal 1961:274 ff., Fig. 140). The shaft-hole adzes are nearly identical to those found at Susa and attributed to protodynastic levels (Deshayes 1960:233, Fig. XXX); the shaft-hole axes are also similar to those found at Susa (Casal 1961:Fig. 139, no. 10, 10a; Deshayes 1960:192, Fig. XXIII, 2).

In Period IV at Mundigak the introduction of a red-slipped ware with black patterns, unconvincingly related to Susa Scarlet Ware (Casal 1964b), and the continuation of the Iranian cross-hatched designs, as well as of naturalistic ibexes and partridges, their stylized counterparts, and floral designs, may mark continuing contact with Iran. The pipal

leaf motif introduced in Period III continues in use; it appears, however, to be purely an Indian motif. A mouflon-headed pin with slightly widened shaft head (Casal 1961:Fig. 139, no. 18) is similar to those of Hissar II (Schmidt 1937:205, Pl.29). A concave disc assigned to this period may have been used as a mirror; it also finds its parallel at Hissar (1937:202, Pl.54).

In Period V, the decoration, fabric, and technology of pottery production change rapidly, with a reversion to handmade pottery. A mat dull purple-red ware, with checkered bands on the upper part of the body vessel painted in purple or purplish-black (similar to Rana Ghundai IIIC), becomes most characteristic. Metal finds of this period are neither extensive nor technologically more evolved. The change to handmade pottery and the apparent decline in the production of the previously more elaborate metal forms (shaft-hole axes and adzes, daggers) may signify a break in western influence and relations and the beginning of a regional florescence following the occupational break evident after Mundigak V.

Unfortunately, in Baluchistan stratified sequences such as those at Mundigak are as rare as they are in the rest of the Indian subcontinent, where large blanks still exist in both space and time. At Quetta (Fairservis 1956: 231) and Ispelinji Mound 1 (*Pakistan Archaeology* 1964:16) copper tools appear in association with Quetta ware. The continued use of stone tools and blades throughout this period [Phase C cultures (Dales 1965:261)] and the limited use of metal suggest that these cultures were still in the Chalcolithic.

During the succeeding Phase D, the first settlements in the Indus Plain appear (Dales 1965:262–268). These sites are found in the Behawalpur region (*Pakistan Archaeology* 1964:35–36), throughout northern Rajasthan (*Indian Archaeology* 1958/59:132 ff), in Kot Diji (*Pakistan Archaeology* 1964:39–43), and in Kalibangan (Lal 1962, Thapar 1965). Dales suggests (1965:263) that the lowland settlements sprang from a tradition basically different from the highland tradition of the Baluchi hills, although interaction can be seen at the earliest stages between the two. Evidence for the origin of these lowland settlements is still lacking, though suggestive evidence points to a northwestern stimulus, through Afghanistan and beyond; interest in them lies in the possibility that one (or possibly a number of them) may be proto-Harappan. Although metals are scarce in stratified sequences in central and southern Baluchistan, and not reported at all in the Zhob-Loralai region of northern Baluchistan, this is probably due to the limited excavations conducted in these areas. Metal fragments found at Amri from the lowest levels are coexistent with Togau C ware (Casal 1964b:27,149). Amri ware appears for the first time at Amri in IC, and continues side by side until Harappan ware becomes more dominant in Period III. It would appear that at Amri, as at Kot Diji, a mature Indus culture imposed itself on the native indigenous population. Thus, the pre-Harappan "Sothi," or "Kalibangan," ware at Kalibangan did not develop into mature Harappan any more than did the pre-Harappan Kot Diji ware (Ghosh 1965:115). If, indeed, Mackay's deep digging in the DK area at Mohenjodaro in 1932 (Mackay 1938:441) (which because of the high watertable at the site still left 20 to 25 feet of occupational debris unexcavated [Dales personal communication]) yielded Quetta Wet Ware and "Sothi" pottery, as Ghosh (1965:116) seems to think, they must have been associated with copper and copper-tin bronze tools from up to −33.4 feet. If the evidence and interpretation of Ghosh are correct, then at Mohenjodaro there was an overlap of Harappan and pre-Harappan settlement; but it does not appear that the Harappan developed directly from this predecessor.

Sir Aurel Stein's (1929) soundings in a number of mounds about Baluchistan produced little attributable to Dales's Phase C or Phase D (1965). A simple copper pin, flat axe, and mirror from Kulli; an ornamental pin from Pak in the Kolwa Valley; a copper bracelet from Nundara; and copper fragments from Siah Damb, Moghul Ghundai in the Zhob, and Zayak in Kharam give us few materials upon which to form an opinion, except that copper was used by these peasant communities *ca.* 2500 B.C. The more extensive finds at Mehi—bracelets, pins, mirrors, and a cup—may be contemporary with and find parallels at Harappa I, II (Piggott 1946: 15–21). At Nal, Hargreaves (1925) recovered copper axes, knives, blades, ornamental ring bracelets, and simple pins. The copper axes from Nal, with their tendency to curved sides and narrow butts (Hargreaves 1925:176), do

not conform to Harappan types. N. G. Majumdar's (1934) systematic excavations in Sind yielded very few copper objects. A copper chisel found at Othmanjo-Bithi was believed to be the only object found associated with pre-Harappan pottery (Majumdar 1934:27, 30,Pl.10). The facts, however, that some of the sherds have a typical Harappan trefoil pattern and that the chisel is similar to Harappan ones cast some doubt as to the pre-Harappan identity of the site. Other copper objects found by Majumdar (1934) at Arabjo-Thana, Jhukar, Lohunjo-daro, Lohei, Ghazi, Ali Murad, Dhal, Karchat, and Jhangar are of early Harappa date or later. At Sut-kagen-dor, Stein (1931:64–65) uncovered a barbed fishhook that is identical to the fishhooks used at Harappa (described below). About the Zhob River Valley small isolated finds of copper, as at Rana-Ghundai and Dabar Kot, do not provide sufficient evidence for dating or comparison.

The stratigraphic sequences for the earliest levels of the Indus sites are for the most part confused and provide little opportunity for ordering. In the lowest levels are found copper objects manufactured by cold-hammering, raising, and open-mold casting (Mackay 1948: 36). The use of these techniques at Harappa and Mohenjodaro may be explained only as the result of a full-blown metallurgy being introduced from the west. We must bear in mind, however, that these same techniques were part of the common heritage of the north India area, going back to Mundigak II, III. Thus, "the west," in this case, may mean the western Baluchi area, Afghanistan, or the hills about Quetta, where the earlier stimulus for metallurgical development was derived from Iran.

KNOWN SOURCES OF ORE DEPOSITS

Tin sources are very rare in India and unknown in Baluchistan; copper ores, on the other hand, while relatively rare in India, exist in rich deposits in Baluchistan and Afghanistan. The only substantial tin deposits in India exist in the Hazaribagh District; according to Marshall (1931:483) they were worked in ancient (undated) times. Tin deposits occur in the Kara Dagh region of northwestern Iran, as well as in Luristan and Khuzistan (Caldwell and Shahmirzadi 1966: 4), in southwest Afghanistan, and along the coasts of Trucial Oman, from whence it was likely to be exported by sea or overland by the Khyber or Bolan Pass (Fairservis 1956:27) or along the Makran Coast to the Indus (Dales 1962:86–92). The relative scarcity of prehistoric bronzes in the Indus Valley may be due to the dearth of nearby tin deposits. Tin must have been one of the many consumable imports traded for, overland and by sea. The presence of tin, as well as copper, ingots is well attested for at Harappa (Coghlan 1951: 71), and at Chanhudaro copper-tin bronze ingots in alloy form have been found (Mackay 1943:175).

Copper ores are relatively scarce in the subcontinent (Marshall 1931:482). The nearest deposits of copper are situated to the west of the Indus Valley and are unknown in Sind. In Baluchistan, however, rich copper deposits occur at Shah Bellaul and at Robat, where there is evidence of prehistoric (undated) copper smelting operations (Marshall 1931: 676). Large quantities of slag noticed in many prehistoric sites in southern Seistan suggest that copper was also locally available in this region (Fairservis 1961:98). Deposits also occur in the Ros Kuh and Kojak Amran Range. Rich veins of copper ore exist in the Shah Maksud Range in Afghanistan, as well as at Kalel Zeri and Anarek in Iran; at both sites there is extensive evidence for prehistoric copper-working (Marshall 1931:483; Gordon 1950:80–81; Lamberg-Karlovsky 1965:180–184). In India, copper mines near Rohira, in Sirohi State, and near Mewar, Khetri, and Singhana, in the Jaipur State, are believed to have been worked in prehistoric (undated) times. Other important copper deposits are known from Singhbhum in Bihar, Orissa, from Rupavati in the Amreli District, and from Indore (Marshall 1931:676; Lamberg-Karlovsky 1965:183–186).

The presence of lead in many of the copper objects at Mohenjodaro is noteworthy, as copper ores associated with lead occur in Afghanistan and Baluchistan and may be indicative of the source of copper brought in by trade to the Indus Valley (Marshall 1931:483; Gordon 1950:80–81). The presence of nickel in many of the copper implements at Mohenjodaro and a similar percentage of nickel in the copper deposits in Oman suggest a possible trade between these two areas (Gowland 1912: 252). The Indus site of Lothal on the Gulf of Cambay may have been the port through which this copper, either in ore form or in ingots, was received. The deposits of Jabal al

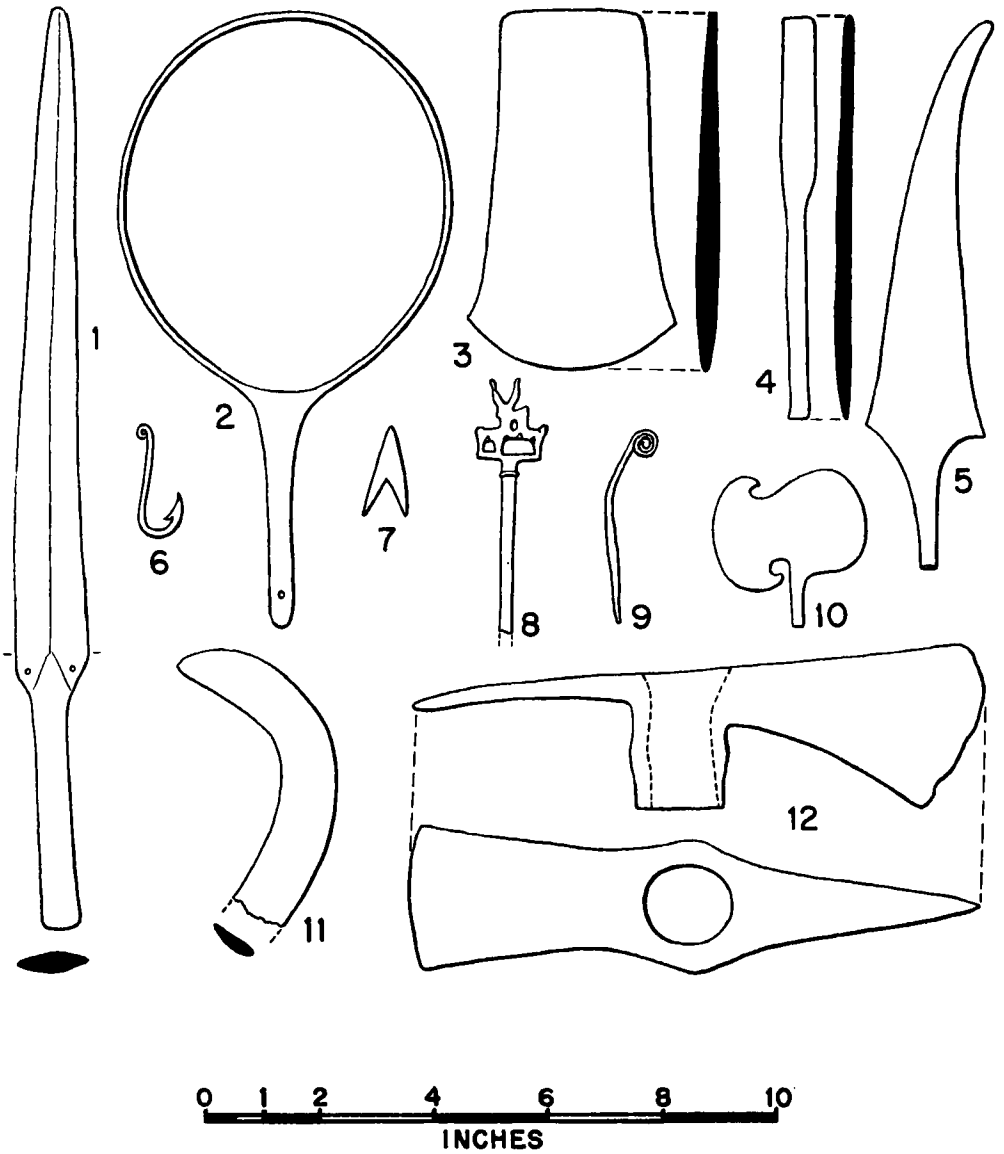


FIGURE 1. Copper and bronze objects from Harappa (5, 8) and Mohenjodaro (the rest): 1, dagger; 2, handled mirror; 3, celt; 4, chisel; 5, knife with curved end; 6, fishhook; 7, arrowhead; 8, animal-headed pin; 9, spiral-headed pin; 10, razor; 11, sickle; 12, socketed adze-axe.

Ma'adan in the Wadi Ahin in Oman contain both nickel and arsenic as impurities in almost the same amounts as an analyzed copper fragment from Mohenjodaro (Gordon 1950:80–81).

The Indus seals found at Ur and the Akkadian period of occupation at Tell Asmar (Frankfort 1939:304 ff.) provide a link with the centers of Mesopotamian metallurgy, while unmistakable proof of contact with Bahrain and other Persian Gulf islands is found at Lothal (Rao *et al.* 1963:180). By the late third millennium copper was being exported into Mesopotamia from Magan and Maluhha, mentioned in cuneiform texts and perhaps Persian Gulf centers; and during the reign of

the Larsa kings, the deposits of Dilmun (Bahrein?)[2] were being tapped (Lamberg-Karlovsky 1965:10). In return for this ore Lothal must have provided ivory, chank shell, stone beads, and cotton (Rao *et al.* 1963:180).

Copper deposits in which the ore is associated with nickel are also found in India, in Rajasthan and Singhbhum (Gowland 1912: 252), and Gordon (1950:81), in considering the distribution of copper deposits, has suggested that the spread of Harappan settlements along the Sarasvati River resulted from the presence of the copper mines in Rajasthan and in southwest Punjab. But until sufficient samples from Indus sites are analyzed, it is not possible to assign the origins of their copper ore to a given provenance. Trade with Oman, however, is more than likely to account for at least part of the copper of the Indus Civilization.

METALLURGICAL TECHNOLOGY IN THE INDUS VALLEY

In considering the metallurgical industry in the prehistory of India, it becomes readily evident that there were two separate, though possibly partially overlapping centers: that about the Indus Valley and allied sites of northern and western India and that about the Ganges-Jumna Basin. Though some typological similarity of objects between these areas is evident—for example, flat axes—it is best to treat the areas separately and then investigate typological and technological similarities. The Indus Civilization, chronologically earlier, merits first consideration.

The absence of a clearly observable developmental sequence, stratigraphically defined, does not hinder one from an analysis of the over-all metallurgical technology in the Indus Valley. Recent excavations at Rangpur, Kalibangan, and Lothal have provided an initial stratigraphic sequence, but have not shown that there was any great development in metallurgical skills from the inception of this civilization to its decline. From the earliest excavated levels, techniques are evident that are also characteristic of the later mature Harappan. At Rangpur during the IIA period (Harappan), low copper-tin bronze objects were normally produced, but the benefits of a higher tin content in the alloy were also realized (Rao *et al.* 1963:149). The absence of arsenic in the Rangpur bronzes and its presence in those of Harappa (2–7%) suggest that different ore sources or alloys were preferred (Rao *et al.* 1963:149).

A great diversity of copper and bronze objects has been found in all Indus Civilization sites. These include Harappa, Mohenjodaro, and Chanhudaro, as well as many of the newer sites discovered in Gujarat and Sind, as far as Kalibangan (reported in *Indian Archaeology* 1958–59). Those objects that appear most abundantly and are readily identifiable are: flat axes, chisels, fishhooks, bracelets, arrow- and spearheads, razors, knives, kohl sticks, mirrors, and saws. The flat axes, usually stocky and of subrectangular form with splayed edges, and the mirrors were cast in open molds (Gordon 1958:66). The chisels and thick-bladed knives were hammered from square- or round-sectioned rods (Smith 1907: 234). All of the objects of thin section, i.e., knives, arrows, spearheads, razors, and saws, were chiseled from sheets of thin roll hammered copper (Mackay 1948:94–96). The hardness of most of the copper objects found at Harappa has been shown on analysis to be due to a high arsenic content. The presence of this arsenic is believed to be accidental, being indigenous to the copper deposits from which the ores were extracted rather than secondarily introduced (Coghlan 1951:44–46). We must not disregard the possibility, however, that the smiths recognized the advantages of an ore with arsenic in it for producing a harder, less brittle tool; since ore selection may have been done by color, it is possible that the smiths remembered what color ore gave the best results and selected for that, thus selecting for arsenic at the same time. Analysis has shown, though, that the Indus metallurgists did add tin to copper, thereby deliberately producing the alloy bronze (Gordon 1950:73). They do not seem to have used a fixed proportion of tin to copper, however, for the amount of added tin varies between 8 and 26 percent (Mackay 1948:94). At Rangpur the amount of added tin varies from 4 to 11 percent, with most of the objects being either of native copper or of a low-tin bronze (below 6%). The only high copper-tin bronzes were bangles and pins (Rao *et al.* 1963:153), perhaps because sheet bronze, from which these objects were produced, is almost impossible to work in a low tin range, either hot or cold, and tends to be too brittle for use as tools (Coghlan 1960: 145).

Through the objects recovered from the

Indus sites, the techniques of hammering, alloying, raising, hollowing, sinking, open- and closed-mold casting, *cire perdue*, riveting, lapping, soldering, and "running on" are known to have been practiced.

Pans, pots, and bowls of copper and bronze occur in the earliest excavated levels at Mohenjodaro, designated by Marshall as Period I (Marshall 1931:478–482); the copper-tin bronze pots and bowls have an almost exact counterpart in pottery (compare Marshall [1931] Plate 160, 1 and 2 with nos. 55–58, Plate 81). For deeper vessels the technique known as "raising" was employed (Coghlan 1951:91). This method entails shaping the pot from a flat disc of copper or bronze by repeated hammering on the outer surface, while the inner side of the pot is slowly revolved against the metal worker's stake. In this manner the metal is raised up through a series of concentric rings. The shallow pans and bowls were produced by an even simpler technique, that of hollowing or "sinking." In this instance the metal is placed over a cup-shaped depression of wood and hammered and turned until sunk to the required depth and shape (Lal 1951:137; Gordon 1958:66). The above techniques are well represented in the metal assemblage at Mohenjodaro (Mackay 1938: 32) and at Harappa (Marshall 1931:481), as well as Lothal (Lal 1963).

A few pans with handles are found at Mohenjodaro and at Chanhudaro. The handles of these pans were formed by bending metal over or under in tubular form, an art known from at least the time of Mundigak IV_1 (Casal 1961: fig. 40, 21). In one instance a tubular handle was lapped onto the body of the pan (Mackay 1938:Pl. CXXII). In addition to these rather uncomplicated methods of production, bronze and copper objects were made in open and closed molds or by *cire perdue* technique. In the early levels at Chanhudaro metal objects were manufactured by the relatively simple process of hammering as well as by casting; stone molds for the casting of flat axes were found (Mackay 1943:117–119).

It is difficult at this stage of research to assign the development or introduction of the complex *cire perdue* technique of casting to a particular period. The bronze figurines from Mohenjodaro, however, are certainly not from the latest mature Harappan period (Marshall 1931:345; Wheeler 1962:72). Axes cast in closed molds are found at an equally indeterminate, but not late, date (Mackay 1938:452). A highly sophisticated development in Indus metallurgy can be seen in the joining of two parts of a bowl or jar by lapping. It is most probable that bowls with sharply carinated shoulders were made in two portions by raising and then joined by lapping (see Mackay 1948: Pl. XXII; Gordon 1958: Pl. IX). Besides lapping, rivets were used for joining separate sheets of metal in vessel production (Lothal AIII period provides a good illustration, *Indian Archaeology* 1955/56, Plate XIA).

There have been no reported instances of copper soldering in the Indus Valley, although the knowledge of this technique is seen in the gold and silver work (Marshall 1931: 486–489; Mackay 1948:136; Lal 1953:80–89). It is interesting to note that soldering was first used in Mesopotamia on gold and silver objects also (Lamberg-Karlovsky 1965:118). A technique similar in function to soldering, "running-on," was employed to reinforce rivets by running molten metal about the base of the rivet for greater strength (Marshall 1931:489).

It is evident that the smiths of the Indus Civilization displayed a sophisticated command over their metallurgical techniques. Very little is known, however, of their furnaces, bellows, or crucibles. This is also true for their tools of production; none have been found that could be definitely designated as the tools of a smith. A short distance south of the Great Bath building at Mohenjodaro (DK area, G Section), a large and apparently important building was uncovered, which the excavators believed served as the accommodation for metal workers (Mackay 1948:47). A considerable amount of copper ore in a brick-lined pit indicates that copper was smelted and possibly cast there. The brick-lined pit may have served as a reducing pit for copper. Furnaces of the "pot" type, 3 feet 4 inches in diameter and 8 inches deep, into which the blast must have been forced downward through oblique channels by some sort of efficient bellows, were identified at Harappa (Vats 1940:470–472). Unfortunately, only this single furnace has been identified out of the many that must have been used for metal production.

The most common metal tool found at Mohenjodaro and Chanhudaro is the chisel. This, due possibly to coincidence, is not so at

most of the other Indus sites, where the flat axe is the most common metal type. The chisel typically acts as a sharp-edged tool for cutting or shaping wood, stone, or metal. The numerous finds of metal chisels cause one to speculate as to their function. Metal does not appear to have been cut and shaped by chisels in sufficient quantity to cause such a demand and subsequent supply; nor was stone-working common, and when present it was crudely done. We are left to conclude that these chisels were used for the shaping and cutting of wood, which has not survived. There are five different types of chisels (Mackay 1938:184 ff.), all of which appear to have been produced by simple hammering.

Blade-axes of a simple form are common, and basically of two different types: long and narrow and short and broad. Both types have double shaped lunate edges, slightly sloping sides, and square-cut butts. The short and broad ones seem to be more common outside of the Indus Valley proper (*Indian Archaeology* 1956/57:16; Rao *et al.* 1963:149). They appear to have been manufactured in the same manner as the blade-axes of the Ganges-Jumna Basin (though the butts are thinner in section): cast in molds and finished with the aid of a hammer and an abrasive.

In certain respects the short and broad blade-axes of Mohenjodaro resemble those from the Gungeriā hoard attributed to the Ganges Civilization. Typological similarities of these blade-axes in the Indus and the Ganges are often based on the presence of an incipient shoulder, which is pronounced in both types (Marshall 1931:495; Wheeler 1966: 94–95). It is to be emphasized that this is a common characteristic, functional for a blade-axe, and need not show cultural contact or derivation; nearly identical shouldered blade-axes are known from Hungary and Western Europe in the Bronze Age (Childe 1929:203–208). The blade-axes at Chanhudaro exactly duplicate those of Mohenjodaro. An axe with a definitely pronounced shoulder has recently been uncovered in the Harappan levels of Lothal (*Indian Archaeology* 1957/58:13, Plate XXIA).

The presence of a unique metal saw at Harappa and, indeed, the constant presence of saws at other Harappan sites suggest a great dependence on this tool. In the early metal saws, excepting the Mohenjodaro example (Mackay 1938:Pl. 116), the teeth do not appear to have any distinct direction; the saw was simply an abrading instrument for scraping out a groove by pulling and pushing (Marshall 1931:500–501). The saw from Mohenjodaro, on the other hand, has its toothed edge undulated in order to prevent binding in a cut. This is the first evidence for the use of the true cutting saw, which, except for this example, does not occur prior to the European Iron Age (Coghlan 1951:79–83). Its presence suggests that the Harappans had developed a dependency on and need for cut wood. The great number of chisels tends also to support this theory. The wooden beam rafters in the larger architectural structures, as well as the wood needed for fuel to fire their metal- and brick-producing ovens, were doubtlessly cut with such saws. None of the four saws found at Mohenjodaro or of those from Harappa and Chanhudaro was found in association with other objects. A saw from Lothal, believed to have been used in bead making, was found associated with a mirror, a drill for bead work, and blades, all dated to the Harappan level of Lothal. Another saw may have been used in woodworking (*Indian Archaeology* 1959/60:17).

The beam balance for weighing scales must have been of considerable size, to judge from the copper scale pans (Mackay 1938:178; Pl. LXII). These scale pans consist of a circular, slightly hollowed pan with three holes for its attachment and suspension from the beam.

Two copper swords, thickened toward the middle in section but without a true midrib, were also found at Mohenjodaro (Mackay 1938:487). They are of the simplest manufacture, without any distinctive traits of production or decoration. When two examples of a basic and simple object, such as this sword, are separated by a thousand miles and are centuries apart, to point out typological similarities is rather fruitless and certainly misleading; nonetheless, it might not be untoward to call to mind the dagger fragment found in Seistan, also with a thickened middle, and in association with a mirror, a flat celt fragment, and a haft fragment from a copper knife (Fairservis 1961:98, fig. 32).

Spear- and arrowheads with pointed wing barbs are quite numerous. They occur from the earliest excavated levels at Mohenjodaro (Marshall 1931:497). These spear- and arrowheads are notable for the width and thinness of their blades: some are so thin that unless

they were reinforced they would have buckled under the most moderate pressure. They appear to have been reinforced by a wooden midrib or to have been hafted onto a split wooden shaft acting as a midrib. Mackay (1938:487) suggests that these arrow- and spearheads were not made by the people of Mohenjodaro, but represented captured booty from an "inferior civilization." The fact, however, that they are found throughout all levels of Mohenjodaro and at Harappa militates against this hypothesis. Spearheads are found in considerable abundance on all Indus sites. As an implement of warfare they would not have been efficient, being too light and thin, but it is possible that they were used as spearheads for fishing. In all cases they appear to have been manufactured by cold-hammering.

Fishhooks hammered round in section are common on all Indus sites. They are, for the most part, of copper with a simple end barb and punched eye at the end of the shank to secure the line (Marshall 1931:501).

Razors of the Indus Civilization take a variety of forms. The most common type has opposite blades of dissimilar shapes at the end of a long rodlike handle. The second type is L-shaped; the third has a handle that bends backward parallel with the blade. The fourth, and rarest, type consists of a long, thin, straight blade with a rounded edge at one end (Gordon 1950:80–83). All of these types were found also at Chanhudaro (Mackay 1943:182), which added two new types to the inventory: distinctive U-shaped and crescent-shaped forms. Razors have been found, too, at Rangpur and Lothal, but descriptions are not reported (Rao *et al.* 1963:149). Mackay (1943: 183) believed that all but the thin straight blades with rounded edge were peculiar to India.

A number of copper figurines are known from the Indus Civilization. Among them are several of animals. Bulls with lowered head and marked hump have been found on all Indus sites, and an elephant (?) is known from Mohenjodaro (Mackay 1938:100). Birds have been identified from Mohenjodaro and Harappa; the example from Mohenjodaro has its eye-holes drilled, doubtless to take inlays. Rather similar to this is a bird-headed pin from Lothal (Rao *et al.* 1963:181). Fragments of other animals are also known, although with these the exact species is hard to determine; the figure of the Mohenjodaro "elephant" and that of the Lothal "dog" fall into this class. Copper figurines of wagons and carts are found at some of the Indus sites, for example, Mohenjodaro (Marshall 1931: 209). Human figurines cast in copper-tin bronze are also known.

A most remarkable figurine is that of a girl found in HR area and ascribed to the "Late Period" of Mohenjodaro (Mackay 1938:138). This bronze figurine depicts a young female, apparently dancing, naked except for arm bangles and a necklace. It stands 4.25 inches high, with the feet broken off. The right hand rests on the hip, the left hangs loosely, the posture of the legs is relaxed. The head, expressively tilted, is a skillful impression of "australoid" characteristics, with large eyes, a flat nose, somewhat prognathous face, and bunched (or braided) hair. Another figurine of a dancing female was found at Lothal (*Indian Archaeology* 1956/57:16). Both of these figurines, as well as most of the animal figurines, are eloquent testimony to the Indus artisans' mastery of the *cire perdue* technique of casting.

In the metal inventory of the Indus Valley sites, only a very limited number of objects can be ascribed a purely military function. Four daggers with pronounced midrib from Mohenjodaro provide the exception to this (Mackay 1938:123). All four have a long tang, with rivet holes at the base of the blade on either side of the tang. Two of these daggers, 18.5 inches and 15.7 inches long, were found in Period Ib and II (1938:120). These weapons are late, and foreign to the Indus metal material culture. Nor do these four daggers have a parallel in the Ganges-Jumna Basin. Schaeffer (1948:fig. 145) provides a close parallel for them at Megiddo, dated *ca.* 2000 B.C. A fragment of a similar midribbed blade, with most of the blade and tang missing, is known from Navdatoli, Period III (*Indian Archaeology* 1958/59:fig. 14); it is closer in both time and space to the Mohenjodaro examples than the Megiddo parallel. The appearance of these midribbed daggers, as well as of a cast single-socketed copper axe-adze found at Mohenjodaro (Mackay 1938:457–458), has been attributed by Wheeler (1961:240) to the expansion of warrior peoples who brought with them, *ca.* 1800 B.C., the widespread distribution of improved metallic weapons.

The simple socketed axe-adze from Mohenjodaro closely resembles ones from Hissar (Schmidt 1937:Pl.52) and Shahi Tump (Stein 1931). At Hissar this axe was found in IIIC

context (Schmidt 1937:205). A macehead from Mohenjodaro, dated to *ca.* 2000 B.C. (Piggott 1947:31), also is typologically similar to one from Hissar IIIC (Schmidt 1937:Pl.52). Similar maceheads are known in Luristan, and dated there to *ca.* 1400 B.C. (Piggott 1947:39–41). Further chronological discrepancies are evident if the socketed axe-adze from Chanhudaro is considered (Mackay 1943:188). Typologically it is identical to the one from Mohenjodaro. At Chanhudaro this axe-adze was found in stratum III and dated *ca.* 1200–1500 B.C., or five hundred years later than its identical counterpart at Mohenjodaro. The axe-adzes at Chanhudaro and Mohenjodaro have been assigned to the Jhukar Culture (Piggott 1947:42–47); if this designation is correct, then the lower date of 1500 B.C. is more acceptable for them than the higher date of 2000 B.C.[3] Spiral-headed and animal-headed pins found at Mohenjodaro and Harappa have also been included in the Jhukar inventory; as we have seen, however, spiral-headed pins occur in perfectly good stratigraphic context at Mundigak. The spiral-headed pins found at both Mohenjodaro and Chanhudaro (Mackay 1943:72) are similar to those of Hissar IIB–IIIA (Schmidt 1937:119,205, Pl.29, 45). Bird-headed pins are known from the Harappan levels at Lothal (*Indian Archaeology* 1956/57:18). Further parallels can be pointed out with the copper stamp seals of Chanhudaro II. These compartmented seals, in which there is a raised pattern of metal strips, occur also at Shahi Tump (Stein 1931: Pl.14), at Hissar IIB (Schmidt 1937:Pl.31), at Anau III (McCown 1942:60), at Deh Morasi III (Dupree 1963:114,fig.10c), and at Susa (LeBreton 1957). The idea for producing such objects as animal- and spiral-headed pins, maceheads, and compartmented seals may have been passed on by stimulus diffusion and trade; certainly their wide distribution in both time and space does not make them reliable indicators for establishing chronological synchronisms (Childe 1936:113 ff.).

A simple copper dagger without midrib or medial thickening similar to the type found at Mohenjodaro, Ib and II levels, was found in Manpur in the Bulandshahr District (Sastri 1915:2,Pl.IV). This dagger was associated with two copper axes, excavated from a mound. No attempt was made to excavate this mound further, and we are left to ponder how these axes (not illustrated) and daggers were uncovered in the first place (Gordon 1950:60).

The copper objects recovered from the graves at Shahi Tump are linked by Piggott (1943:178–181) with Anau III, Hissar III, and the Jhukar settlement of Chanhudaro II. Shahi Tump provided the first appearance of the shaft-hole (trunnion) axe in India (Stein 1931:90–94) until the discovery of earlier shaft-hole axes in Mundigak III_6 (Casal 1961: 248, fig. 139,10,10a), Afghanistan. Typologically, the shaft-hole axe from Shahi Tump has been compared with those from Maikop and Tsarskaia in south Russia (Lal 1953:95–97; Joshi 1962:10). The Shahi Tump cemetery seems to have been dug into earlier settlements of the Kulli-Mehi culture (Lal 1953:87). The pottery has been unconvincingly referred to as a late and decadent version of the ceramic tradition of Susa I and Bakun A (Thapar 1965:161). The metal objects, however, at Shahi Tump do reflect the forms found in Hissar IIB and III, as well as Anau II types. Scattered finds such as the celt from Kurram, the bronze sword from Rajanpur in the Punjab, and those from Fathgarh and Kallur, suggest further contacts with the west at different and as yet unknown periods (Thapar 1965: 161).

These shaft-hole axes, midribbed daggers, and swords are believed by some authors to be part of the inventory of the invading Aryans (Heine-Geldern 1936:87–113; Gordon 1950:38). It is not within the scope of this paper to evaluate the abundant literature on the material remains identified as belonging to the Aryans. The trunnion axe from Shahi Tump, the Fathgarh swords, and the Fort Munro sword have, however, all been designated as part of this inventory. Until this problem rests on a firmer foundation, it is to be remembered that typologically similar trunnion axes and midribbed daggers are known from Iran, Palestine, Lebanon, and Russia (Childe 1957:219–228, Pl.39). Too, the daggers and axes from Byblos II–IV, which are typologically similar to those of India, are not associated there with the problem of Aryan invasions and origins (Dunand 1939, Schaeffer 1948).

THE GANGES-JUMNA METALLURGICAL TRADITION

From the Indus Valley we turn eastward to the *doab* or two-river country of Hindustan, the drainage of the Ganges and Jumna rivers. The actual distance from the Sutlej of the Indus system to the Jumna is less than 80

miles, but in prehistory the two valleys are culturally distinct. Slight hints of some connection between the two areas are evident, however, such as the find of what is believed to be an anthropomorphic figure—a typical Ganges form, foreign to the Indus—in Lothal IV (Lal 1964:19) and the occurrence of a copper ring of apparent Ganges affinity at Bargaon, in Saharanpur District, in a Harappan level (Deshpande in Ghosh 1965:128). The archeology of the Ganges Valley is still in its infancy, and extreme caution should be used in making correlations between the Indus and Ganges civilizations. The famous series of copper hoards found over the years in the Ganges-Jumna Basin have been, until very recently, completely devoid of any associations.

In these hoards over one thousand objects have been found on more than 34 sites. The objects comprise eight main types: (1) flat-axes of stocky, subrectangular form with splayed edges, (2) shouldered axes, (3) bar celts or chisels, up to two feet long, consisting of a nearly parallel-sided bar and an expanded chisel edge in one of the lateral planes, (4) rings made by bending a rod of circular section until the ends meet, (5) harpoon heads with bilateral barbs and a loop or projection for the attachment of a cord, (6) spearheads with a midrib, (7) swords, usually with the hilt bifurcated like antennae, and (8) anthropomorphic objects, up to 18 inches in height.

Analysis of some of these objects shows a small amount of nickel and arsenic, in proportions consistent with an Indian origin for the ore (Wheeler 1959:124). It is unlikely that the manufacturers of the distinctive Ganges copper objects were degenerate Harappans developing in isolation, as Ghosh (1965:124) has recently stated. The metal objects characteristic of these hoards are culturally out of context, and without prototypes, in an Indus environment. Although most of the implements are of copper, at least two harpoons and two swords are of low-grade copper-tin bronze (Ghosh 1965:147); the antennae sword from Kallur in the Raichur District contains 9.5 percent of tin (Wheeler 1959:124). Campbell, from his examination of 27 axes from Manbhum (1916), is of the opinion that the axes were produced in closed molds and then beaten to the required thickness while still hot. The metallurgical techniques evident in the production of these hoards are of a skill comparable to that evident in the metals produced in the Indus Civilization. Perhaps, as Gupta remarks, the Ganges people acquired the ideas and techniques from the late Harappans, with whom they came into contact in the course of the Harappans' eastward expansion (Gupta in Ghosh 1965:147).

Only a very few objects characteristic of the hoard types have been found stratigraphically associated with other material. Lal dug exploratory trenches at Rajpur Parsu and Bisauli, where copper hoards had been found, and uncovered sherds of low-fired ochre-washed ware (Lal 1953:80–103; Ghosh 1965: 123). Little is known of this Ochre Washed ware. Its complete repertoire of shapes has not been determined, and its association with the copper hoards, though likely, is not yet proved. It occurs in the lowest strata of Hastinapura, preceding the Painted Grey ware (Lal 1953:80–103), and in the same horizon at Atranjikhera, District Etah (Ghosh 1965:124). It has been collected from the surface at Manpur and Bhatpura, in Bullandshahr from Ambkheri, Saharanpur District, by M. N. Deshpande.

As the picture emerges, it appears as though there are comparable shapes and fabrics at these sites, although there is also a high degree of individuality. The few common shapes so far determined seem to be traceable back to Rupar and Bara (Ghosh 1965:124), but the presence of individual features must not be ignored. There is even some doubt about the Ochre Washed ware being a distinctive group; its apparent fabric may be due to imperfect firing and prolonged burial in waterlogged or saline soil. This would make both the core and the surface soft and liable to rub off easily (Ghosh 1965:154, n. 24). The "dish-on-stand" and the knobbed lid found in Ochre Washed ware are certainly reminiscent of Harappan shapes (Lal 1964:18). However, if the condition of the slip and the fabric is due to waterlogging, we cannot tell what the designs on the surface were like, or even if they existed. Perhaps this ware is then to be connected with the Lustrous Red ware of the late Harappans, or the dull red ware found in the late Harappan level at Bargaon (Deshpande in Ghosh 1965: 129). At Manpur and Bhatpura, the Ochre Washed ware appears to have some connection with Late Harappan ware (Joshi 1962: 19); it certainly occurs beneath the Painted Grey ware, both here and perhaps also in

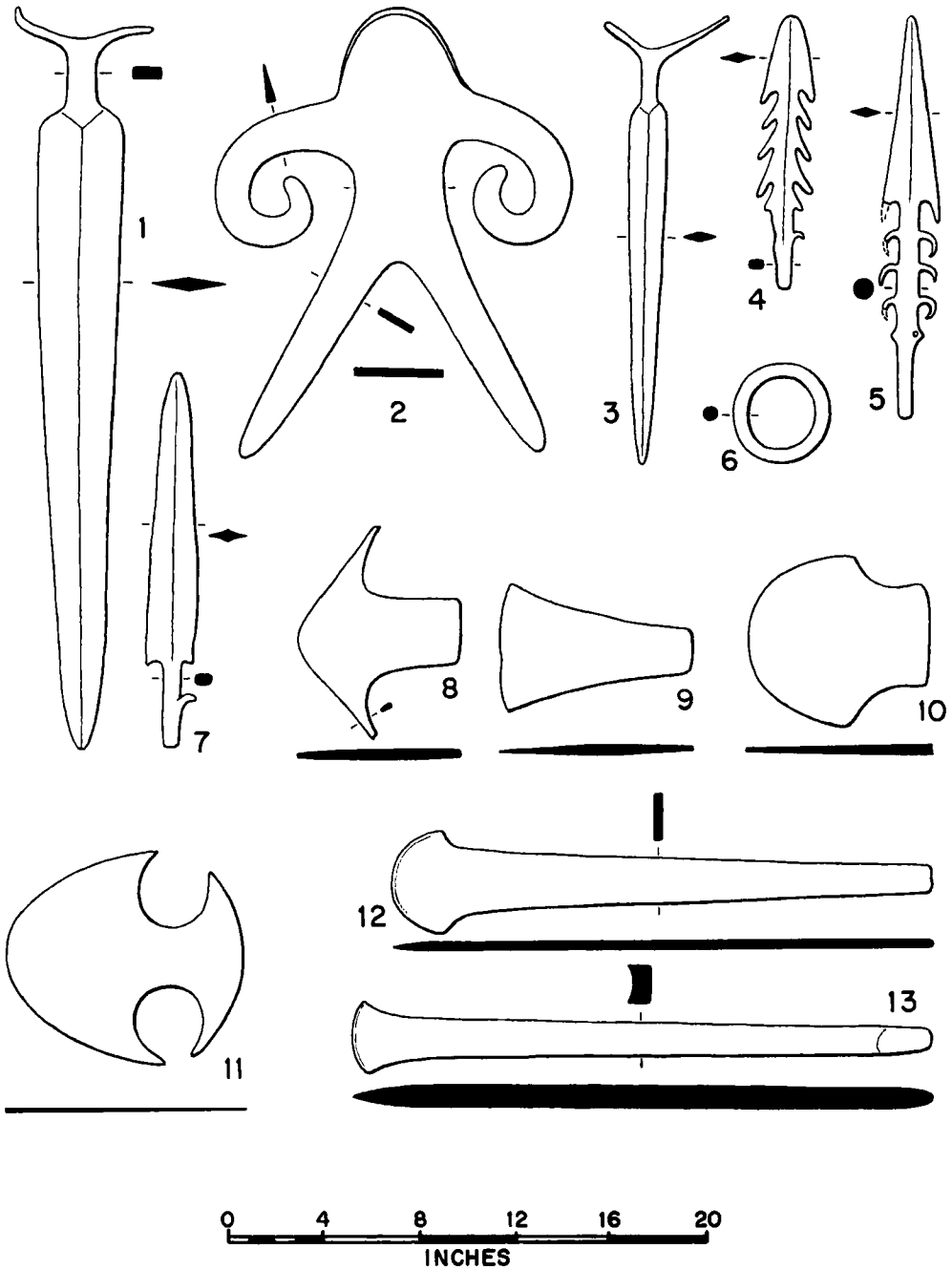


FIGURE 2. Implements and other objects from copper hoard sites: 1,3, antennae sword from Fathgarh; 2, "anthropomorphic" figure from Sheorājpur; 4,5, harpoons respectively from Sarthauli and Bisauli; 6, ring from Pandi; 7, hooked spearhead from Sarthauli; 8, hatchet from Sarthauli; 9, celt from Gungeriā; 10, shouldered celt from Dunriā; 11, double-edged axe from Bhagrā Pīr; 12,13, bar celts from Gungeriā.

Rajghat IA, where an "ochrous red ware" is found in association with black-slipped, coarse black and red, and red and gray wares (*Indian Archaeology* 1960/61:35).

The flat-axe with more or less expanded blades is the only possible link with the Indus Civilization, and the type is too generalized a form and too isolated an element to support the view of Indus colonization about the Ganges (Wheeler 1959:125) or fleeing Harappan refugees (Piggott 1950:238; see also Dales 1964:36–43, 1966:93–100, and Raikes 1964 for an interesting formulation on the decline and evacuation of Indus sites). The really distinctive hoard types—barbed harpoons, bar celts, antennae swords, anthropomorphic figures, shouldered axes, and spearheads—are all foreign to the Indus inventory, as the distinctively curved Indus blade is foreign to the hoards.

The barbed spearheads or harpoons are of two types. The most common, known as the Bithur type (Smith 1905:1–6), consists of a large barbed spear having generally two hooked barbs on either side, below which are a lug and a perforated hole for the attachment of a string. These are generally up to 12 inches in length (Piggott 1944:174–176). Those of the second type are most certainly harpoons, with four to six bilateral barbs equally spaced along the length of the blade (Gordon 1950:fig.1, p. 73). Spearheads of the Bithur type are unique to India. In the cave paintings of Ghomargur and Lakunia, in Mirzapur District, the spearheads of the hunters attacking an animal are almost exactly like those referred to above as the Bithur type (Joshi 1962:18). Smith (1905:236–257) observed that these harpoons are not forms natural to a metal production, but are copies of earlier ones in bone and antler. These prototypes have, however, never been found in this area. The spears and harpoons suggest extensive fishing, as well as the hunting of animals as formidable as the rhinoceros, depicted on the cave paintings (Wheeler 1959:126).

The bar celts are believed by Piggott (1944:173–182; see also Gordon 1958:144) to have evolved from the narrow, elongated copper celts of the type discovered at Nal and Mohenjodaro. Lal's more acceptable view is that these copper bar celts developed from stone prototypes common to the area (Lal 1950). Bar celts of stone are found at Ban Asuria, Jashpur, Thakurania, Daspalla, Sitabhanji, and the Santal Pargana, in Bihar, and overlap the copper types temporally and spatially (Joshi 1962:22). Shouldered celts are also found in stone in India, Burma, and Malaysia and throughout southeastern Asia, as well as in Central India from Dul Barh, Bongra, Manbhum, and Mayurbhani to the mouth of the Godavari (Joshi 1962:22).

The place of origin of the hoard contents is in doubt. Gupta would have them originate somewhere in Bihar or Chota Nagpur, where Burmese shouldered celts are found that are exact prototypes of those of the Ganges hoards (Joshi 1962:22; Gupta in Ghosh 1965:147). On the basis of this theory of eastern origin, the Bihar-Orissa types, namely the flat and shouldered celts, are most common to Uttar Pradesh, while the harpoons, anthropomorphic figurines, antennae-hilted swords, and spearheads all evolved from the Bihar-Orissa types (Misra in Ghosh 1965: 148). Until substantially more evidence is forthcoming, it is best to hold in reserve such theories on the eastern (Joshi 1962) or western (Heine-Geldern 1936) origins of these hoards.

There are two hoards, within the Ganges-Jumna basin, that stand apart and are of outstanding interest. At Fathgarh, a group of 13 swords were found, apparently of copper, although they were never analyzed, with slight midribs. All but one of these have a characteristic antennae hilt. These large antennae swords are paralleled by another hoard of four such swords from Kallur in Hyderabad State, Deccan (*Report of the Archaeological Department* . . . 1937–40:Pl.V). The intrusive nature of these martial swords strikes an immediate discordant note among the axes, harpoons, and spearheads of the primitive peasantry of the Ganges-Jumna Basin; Heine-Geldern (1936:87–113; 1956:146–163) has attempted to assign these weapons to the warlike Aryans of the Vedas. The closest comparable finds of antennae swords are in the Caucasus and South Russia (Piggott 1944:180; Gordon 1950:85–87). The absence of similar finds between these two areas, as well as the chronological discrepancy in their occurrence, presents an enigmatic picture. The Fathgarh and Kallur swords have been most often compared with those of the Koban Culture (Heine-Geldern 1936:124–135; Piggott 1944: 180; Gordon 1950:80–84; Wheeler 1959:115; Joshi 1962:18), but the parallels are unconvincing. Aside from the fact that the Koban

swords are of copper-tin bronze and the Indian examples are of copper, the Koban swords are cast in two pieces, hilt and blade, and then joined by "casting-on," while the Indian examples are cast in one piece. Furthermore, the hilts of the Koban swords have a hole in the center and the blades are flat sectioned, while the Fathgarh and Kallur swords have no hole and the blades have a slight midrib.

A bronze sword with a strong medial midrib, the Fort Munro sword, found in the Punjab and of unknown date, is unique within the entire Indian metallic inventory. The peculiar hilt finds its closest parallel in the "Luristan" swords of Iran. Lal (quoted in Joshi 1962:18) claims that this sword, like the axe of Mohenjodaro and the socketed axes of Shahi Tump, has no relation to any Indian culture and is clearly intrusive. At Fathgarh, however, an anthropomorphic figure of sheet metal and a typical harpoon of the Ganges-Jumna type were also uncovered, both of which may be paralleled by the harpoons and the anthropomorphic figurines found at Bisouli (Piggott 1944:180). Perhaps the occurrence of the antennae-hilted sword in India and in Eastern Europe, as well as in Central Europe in the Late Bronze and Iron Ages, may have something to do with the functional significance of antennae hilts in both areas, or it may be a nonfunctional decorative idea that can appear independently, given the form of a lingtanged sword.

The copper hoard found at Gungeriā represents one of the earliest of the Ganges-Jumna type copper hoards (Smith 1905:245). In this hoard 424 objects were found: predominantly axes and bar celts, along with 102 thin silver plates. The bar celts are typologically similar to those found at Brahmagiri along with fragments of copper and bronze and unfinished ingots (Wheeler 1948:222–252). The axes are all blunt and appear to be unfinished. This would tend to lend some support to the claim that these copper hoards are the products of itinerant smiths (Sharma in Ghosh 1965:134).

From the Deccan, the excavations at Navdatoli have yielded a dagger with a raised midrib and flat antennae (*Indian Archaeology* 1958/59:30). This object is a near duplicate of the Fathgarh daggers. Navdatoli is important because it provides us with a radiocarbon date for a phase associated with a copper object of the Ganges-Jumna hoards: this dagger was found in Navdatoli III, radiocarbon dated to 1600 ± 130 B.C., P-204 (Lal 1963:215). Evidences of contact between the middle and late phases of Navdatoli III and Rangpur IIC and III (Rao *et al.* 1963:198) suggest that the Deccan Chalcolithic may have had some connections with post-Harappan Gujarat. The find of what is considered by Lal as an anthropomorphic figurine of Ganges-Jumna type in Lothal IV (Lal 1964:19), with a radiocarbon date of 1900 ± 115 (TF29) (Lal 1963:213), would move the date of these hoards back even further. Other evidence for raising the date of the hoards comes from the find, in a typical Harappan assemblage at Bargaon, of a copper ring of the type found at Pondi, Bahadarabad, and Jorwe (Deshpande in Ghosh 1965:128; see also Sankalia 1955; 1965:219–235). At Chandoli, an antennae sword was found associated with Jorwe-Nevasa pottery (*Indian Archaeology* 1960/61: 27); this type of pottery first appears in the third period at Nevasa, dated by radiocarbon to between 1228 and 984 B.C. (Sankalia 1960: 68). These hoards, it would appear, and the types represented within them have a long history, beginning as far back perhaps as 1900 B.C. to 1000 B.C. The nonassociation of hoard types with Painted Grey ware implies that they are earlier than 1000 B.C. (Wheeler 1966: 95). It is obvious that a definitive statement cannot be approached at this time.

At the risk of sounding repetitious, I must stress the closely linked metal tradition of the entire north India area, even when the different groups of people were using different types of ceramics. At Navdatoli, Nimad District, Madhya Pradesh, the metallic objects found included five copper flat-axes, wire rings, bangles, nail-parers, fishhooks, chisels, and thick pins of copper or bronze (*Indian Archaeology* 1956/57:8–31), all of which but the chisels would have no difficulty losing themselves in almost any copper assemblage in northern India. Although there are certain variations in the metallic finds—for example, the Nevasa celts are smaller than the Jorwe celts—they are akin in having a slightly convex cutting edge and being oblong in plan (*Indian Archaeology* 1960/61:20). We are faced with a surplus of simple metal objects in the north Indian area, without significant associations and with very little that is complex enough to provide us with enough points to make detailed comparisons.

It is evident that the use of and advantages of low-tin bronze were known in this area. A chisel from Nevasa (Sankalia 1960:417) contained 2.72 percent tin, with traces of lead and nickel, while an associated copper bangle and bead were made of native copper (1960: 523). The techniques used to produce these objects were found out through metallographic analysis: although there was evidence for dendritic segregation in the chisel, as there is in all cast alloys, the dendrites had been broken up by hot forging after casting and finishing just above the recrystallization temperature (*ca.* 500°C); both the bangle and the bead were worked by hot-hammering at a relatively high temperature (1960:524).

The distribution of these techniques, as well as that of the hoards, is still imperfectly known. A recently found hoard at Khurdi in Rajasthan brought to light flat-axes, long bar celts, and a channel-spouted bowl with similarities to distant Sialk and Navdatoli types (Joshi 1962:31, Pl.VIa). The possibility that these objects found in hoards represent the scattered remains of indigenous northern tribes, i.e., Nishadas, Pulindas, Savaras, or possibly a fusion of these, has been suggested by Sankalia (1963:225).

The rather extensive inventory of the metallic implements found in India and Pakistan covers almost all known techniques of a copper-bronze technology. The dearth of stratified metal objects, however, makes a study of its developmental processes almost impossible. Exaggerated claims for typological similarities of objects have been made that disregard chronology or jump thousands of miles without considering the lack of intermediate finds. I have largely ignored these claims, although I have noted similarities that were too general and might well have been the result of contact and trade. The common heritage of metallurgy of Baluchistan and the Indus, and through Baluchistan of northern India, has been noted and offered as an explanation for the complex interrelationships that are found in these areas. The importance of diffusion from the west has been emphasized, possibly more the diffusion of ideas and techniques than the diffusion of forms. As might be expected with the examination of the complex art-science of metallurgy by the complex art-science of archeology, the results can be only tentative and the quest for new data continued.

NOTES

[1] This paper has been substantially revised since its first appearance as a chapter of my Ph.D. thesis for the University of Pennsylvania, Department of Anthropology. I would like to thank Professors George F. Dales and Robert H. Dyson, Jr., for their most helpful aid and suggestions in the initial preparation of this paper. For any errors of omission and commission, I alone am responsible. I am also most grateful to Mr. Arthur Bankoff, who, in my seminar on the archeology of India and Pakistan, reviewed the recent literature on this subject and provided helpful suggestions.

[2] S. N. Kramer has recently argued for the identification of "Dilmun" as the Sumerian collective term for the Indus Civilization sites (see Kramer 1963:111-115). The probable "India trade" via Dilmun (Bahrein?) is recorded in cuneiform texts (see Oppenheim 1954:6–17). The impression on a cuneiform tablet of a Persian Gulf seal, derived from Harappan glyptic style and dated to the tenth year of King Gugunum of Larsa, *ca.* 1923 B.C., serves to date the related examples of Indus glyptic art in Mesopotamia.

[3] This would also suggest, on the basis of metal-type parallels, a lowering of the date of Hissar III to after 1700 B.C.

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